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MOVABLE-WALL COKE OVEN TESTS AND RELATED ANALYSES
OF BLENDS FROM LINE CREEK EXTENSION PROJECT
SUBMITTED BY
CROWS NEST RESOURCES LIMITED

Project No. 03-3-1/11-11
Job No. 3394R

J. G. Jorgensen and T. A. Lloyd
Combustion and Carbonization Research Laboratory

JANUARY 1983

ENERGY RESEARCH PROGRAM
ENERGY RESEARCH LABORATORIES
DIVISION REPORT 83-05 (CF)

Declassified
Déclassifié

CONFIDENTIAL

Declassification Date:
January 1985

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INTRODUCTION

The evaluation of coals for Crows Nest Resources Limited is a continuing divisional project in which periodic investigations are undertaken as requested by the company.

This report is a continuation of Investigation No. 11 in the series and includes evaluation data on coal blends specified in letters dated April 2, 1982, May 6, 1982 and August 9, 1982 from H. S. Stellmach, Manager, Utilization Technology, Crows Nest Resources Limited. Copies of these letters appear in Appendix 1. A description of the blends tested is included in Table 1.

The coal blends were prepared at Birtley Engineering, Calgary and sent to the Energy Research Laboratories, CANMET, Bells Corners Complex near Ottawa. The blends were carbonized in the CANMET 12-inch width movable-wall oven. Representative samples were taken for chemical, physical, thermal rheological and petrographic analyses. The results are tabulated in Tables 2 to 13.

*Head, Petrography Section, **Head, Conventional Carbonization Section, Combustion and Carbonization Research Laboratory, Energy Research Laboratories, CANMET, Energy, Mines and Resources Canada, Ottawa, Canada K1A 0G1

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Table 1 - Composition of blends

BLEND	A	C	D	E	F	G	X-A	X-B
LAB NO.	3488-82	3489-82	3490-82	3387-82	3491-82	3388-83	4187-82	4188-82
COKE OVEN NO.	929	932	933	928	936	927	947	948
SEAM NO.	%	%	%	%	%	%	%	%
3U	10	-	-	50	50	4	10	10
3L	10	-	-	-	-	6	30	-
4U	24	-	-	-	-	15	30	15
6	20	-	-	-	-	10	10	8
7	36	-	-	-	-	17	20	22
8	-	30	50	50	-	10	-	10
10b	-	70	50	-	50	38	-	35

Table 2 - Chemical analyses of component coals

Identification

Laboratory Number.....	3488-82	3489-82	3490-82	3387-82	3491-82	3388-82
Description.....	BLEND A	BLEND C	BLEND D	BLEND E	BLEND F	BLEND G

Classification

Rank (ASTM).....	mvb
International System.....	432
Specific Volatile Index....	186
Carbon (dmmfb).....%	88.7

Proximate Analysis (db)

Ash.....%	9.2	9.6	9.3	9.4	9.3	9.3
Volatile Matter.....%	23.9	21.0	20.8	23.5	23.9	23.1
Fixed Carbon.....%	66.9	69.4	69.9	67.1	66.8	67.6

Gross Calorific Value (db)

MJ/kg.....	
Btu/per pound.....	13975

Ultimate Analysis (db)

Carbon.....%	79.7					
Hydrogen.....%	4.5					
Sulphur.....%	0.54	0.43	0.42	0.58	0.69	0.50
Nitrogen.....%	0.8					
Ash.....%	9.2					
Oxygen (by difference)....%	5.3					

Ash Analysis (db)

SiO ₂%	55.5
Al ₂ O ₃%	26.9
Fe ₂ O ₃%	4.5
TiO ₂%	1.6
P ₂ O ₅%	3.1
CaO.....%	3.3
MgO.....%	0.8
SO ₃%	0.4
Na ₂ O.....%	0.1
K ₂ O.....%	0.8

Table 3 - Chemical analyses of component coals

Identification

Laboratory Number.....	4187-82	4188-82
Description.....	BLEND X-A	BLEND X-B

Classification

Rank (ASTM).....	mvb	mvb
International System.....	433	432
Specific Volatile Index....	181	190
Carbon (dmmfb).....%	89.8	91.3

Proximate Analysis (db)

Ash.....%	9.2	9.5
Volatile Matter.....%	25.3	23.0
Fixed Carbon.....%	65.5	67.5

Gross Calorific Value (db)

MJ/kg.....	13910	13970
Btu/per pound.....		

Ultimate Analysis (db)

Carbon.....%	80.7	81.7
Hydrogen.....%	4.6	4.5
Sulphur.....%	0.57	0.53
Nitrogen.....%	0.9	0.9
Ash.....%	9.2	9.5
Oxygen (by difference)....%	4.0	2.9

Ash Analysis (db)

SiO ₂%	56.6	58.7
Al ₂ O ₃%	27.4	28.8
Fe ₂ O ₃%	5.0	3.8
TiO ₂%	1.6	1.7
P ₂ O ₅%	3.3	2.6
CaO.....%	3.3	2.9
MgO.....%	0.3	0.2
SO ₃%	0.7	0.7
Na ₂ O.....%	0.1	0.1
K ₂ O.....%	0.9	0.5

Table 4 - Physical tests and fusibility of ash of component coals

Identification

Laboratory Number.....	3488-82	3489-82	3490-82	3387-82	3491-82	3388-82
Description.....	BLEND A	BLEND C	BLEND D	BLEND E	BLEND F	BLEND G

Coal Pulverization

Sieve Analysis

<u>Passing</u>	<u>Retained On</u>	1/4 in.	6 mesh	12 mesh	20 mesh%	1/4 in.	6 mesh	12 mesh	20 mesh%	1/4 in.	6 mesh	12 mesh	20 mesh%	
1/4 in.		0.1	0.2	0.5	0.3	0.2	0.2	0.2	0.3	0.4	0.2	0.2	0.2	0.2	0.2	0.2	
6 mesh		10.6	10.9	11.4	13.0	11.9	11.9	11.9	12.3	13.0	11.9	11.9	11.9	11.9	11.9	11.9	
12 mesh		18.0	17.7	18.3	18.8	19.1	19.1	19.1	19.5	19.8	19.1	19.1	19.1	19.1	19.1	19.1	
20 mesh		20.6	19.9	20.4	20.2	20.6	20.6	20.6	20.8	21.0	20.6	20.6	20.6	20.6	20.6	20.6	
Total Passing	6 mesh	%	89.3	88.9	88.1	86.7	87.9	88.6									

Grindability

Hardgrove Index	83
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Fusibility of Ash

Initial Deformation Temp.....°F	2330
Softening Temp Spherical.....°F	2700+
Softening Temp Hemispherical.°F	2700+
Fluid Temp.....°F	2700+

Table 5 - Physical tests and fusibility of ash of component coals

Identification

Laboratory Number.....	4187-82	4188-82
Description.....	BLEND X-A	BLEND X-B

Coal Pulverization

Sieve Analysis

<u>Passing</u>	<u>Retained On</u>		
	1/4 in.	%	0.2
1/4 in.	6 mesh	%	11.0
6 mesh	12 mesh	%	18.4
12 mesh	20 mesh	%	19.9
20 mesh%		52.4
Total Passing	6 mesh	%	88.9
			88.7

∞

Grindability

Hardgrove Index

Fusibility of Ash

Initial Deformation Temp.....°F	2475	2570
Softening Temp Spherical.....°F	2690	2700+
Softening Temp Hemispherical.°F	2700+	2700+
Fluid Temp.....°F	2700+	2700+

Table 6 - Thermal rheological properties of component coals

Identification

Laboratory Number.....	3488-82	3489-82	3490-82	338/-82	3491-82	3388-82
Description.....	BLEND A	BLEND C	BLEND D	BLEND E	BLEND F	BLEND G

Linear Expansion

Bd. 52 lb/ft³ at 2% moisture...%

Gieleler Plasticity

Start.....°C	434	443	447	435	430	435
Fusion Temp.....°C	448	458		448	442	448
Max Fluid Temp.....°C	463	470	469	463	464	465
Final Fluid Temp.....°C	488	487	481	482	487	486
Solidification Temp.....°C	491	493	488	484	491	491
Melting Range.....°C	54	44	34	47	57	51
Max Fluidicity.....dd/m	37.3	11	4.5	15	105	35.5
Torque.....g.in.	40	40	40	40	40	40

6

Dilatation

Ti - Softening Temp.....°C	407	408	411	405	399	402
Tii - Max Contraction.....°C	456	461	471	461	449	456
Tiii - Max Dilatation Temp....°C	476	477	-	476	474	479
Contraction.....%	23	24	23	24	26	23
Dilatation.....%	-12	-21	Nil	-20	6	-9

Free Swelling Index

F.S.I.....	8	7	5½	7	8	7½
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Table 7 - Thermal rheological properties of component coals

Identification

Laboratory Number.....	4187-82	4188-82
Description.....	BLEND X-A	BLEND X-B

Linear Expansion

Bd. 52 lb/ft³ at 2% moisture...%

Gieleler Plasticity

Start.....°C	431	434
Fusion Temp.....°C	445	448
Max Fluid Temp.....°C	462	465
Final Fluid Temp.....°C	483	487
Solidification Temp.....°C	486	491
Melting Range.....°C	52	53
Max Fluidicity.....dd/m	45	37
Torque.....g.in.	40	40

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Dilatation

Ti - Softening Temp.....°C	402	402
Tii - Max Contraction.....°C	449	452
Tiii - Max Dilatation Temp....°C	476	477
Contraction.....%	21	22
Dilatation.....%	10	-5

Free Swelling Index

F.S.I.....	7	7½
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Table 8 - Petrographic analysis of component coals

Identification

Laboratory Number.....	3488-82	3489-82	3490-82	3387-82	3491-82	3388-82
Description	BLEND A	BLEND C	BLEND D	BLEND E	BLEND F	BLEND G

Distribution of Vitrinite Types

V-6.....%						
V-7.....%						
V-8.....%	0.6			0.5		
V-9.....%	1.3			11.3	7.4	3.4
V-10.....%	17.5		0.8	23.7	21.1	13.4
V-11.....%	31.9	3.9	4.6	13.5	7.4	24.6
V-12.....%	11.3	26.7	24.2	4.3	11.4	10.6
V-13		12.1	12.2	0.5	9.1	4.0
V-14.....%		0.4			0.5	
V-15.....%						
V-16.....%						
V-17.....%						
V-18.....%						

Reactive Components

Total Vitrinite.....%	62.6	43.1	41.8	53.8	56.9	56.0
Reactive Semi-fusinite (1/2)....%	11.6	20.2	19.8	15.9	14.6	14.6
Exinite.....%	0.4	0.0	0.0	0.3	0.4	0.3
Total.....%	74.6	63.3	61.6	70.0	71.9	70.9

Inert Components

Inert Semi-fusinite (1/2).....%	11.6	20.2	19.8	15.9	14.6	14.6
Micrinite.....%	2.5	3.6	6.4	3.2	3.5	3.8
Fusinite.....%	6.1	7.6	7.0	5.6	4.7	5.5
Mineral Matter.....%	5.2	5.3	5.2	5.3	5.3	5.2
Total.....%	25.4	36.7	38.4	30.0	28.1	29.1

Petrographic Indices

Mean Reflectance.....%	1.12	1.27	1.27	1.07	1.14	1.14
Balance Index.....	1.07	2.49	2.63	1.20	1.25	1.31
Strength Index.....	4.35	4.87	4.79	4.04	4.45	4.42
Stability Index.....	59.5	47.8	45.4	53.9	58.5	57.2

Table - Petrographic analysis of component coals

Identification

Laboratory Number.....	4187-82	4188-82
Description	Blend	Blend
	X-A	X-B

Distribution of Vitrinite Types

V-6.....%		
V-7.....%		
V-8.....%	0.7	
V-9.....%	10.4	2.2
V-10.....%	35.3	10.5
V-11.....%	15.9	20.5
V-12.....%	6.8	17.2
V-13		5.0
V-14.....%		
V-15.....%		
V-16.....%		
V-17.....%		
V-18.....%		

Reactive Components

Total Vitrinite.....%	69.1	55.4
Reactive Semi-fusinite (1/3)....%	5.6	14.9*
Exinite.....%	0.7	0.4
 Total.....%	 75.4	 70.7

Inert Components

Inert Semi-fusinite (2/3).....%	11.0	14.9**
Micrinite.....%	4.3	4.1
Fusinite.....%	4.1	4.9
Mineral Matter.....%	5.2	5.4
 Total.....%	 24.6	 29.3

Petrographic Indices

Mean Reflectance.....%	1.07	1.16
Balance Index.....	0.92	1.40
Strength Index.....	4.06	4.51
Stability Index.....	56.2	56.6

*Reactive Semi-fusinite (1/2) ** Inert Semi-fusinite (1/2)

Table 10 - Carbonization data

Test Identification Number.....	929	932	933	928	936	927
Date of Test.....	1982-07-08	1982-07-15	1982-07-20	1982-07-07	1982-07-27	1982-07-06
Laboratory Number.....						
Description.....	BLEND A	BLEND C	BLEND D	BLEND E	BLEND F	BLEND G

Carbonization Data

Net Weight of Charge (wet).....lb	588.3	590.9	591.2	583.5	582.4	585.8
Moisture in Charge.....%	3.0	3.0	3.1	3.0	3.0	3.1
ASTM Bulk Density (wet).....lb/ft ³	48.6	48.5	48.6	48.5	48.7	48.7
Oven Bulk Density (db).....lb/ft ³	50.5	50.7	50.6	50.0	49.9	50.2

Carbonization Results

Gross Coking Time.....h:min	9.35	9.35	9.10	0.45	9.20	9.10
Maximum Wall Pressure.....lb/in ²	0.71	0.41	0.34	0.39	0.74	0.47
Coke Yield Actual.....%	77.1	78.4	78.7	75.9	78.1	76.6
Mean Coke Size.....in.	2.01	1.92	1.96	2.01	1.89	1.96
Apparent Specific Gravity.....	0.947	1.013	1.002	0.971	0.949	0.953

Screen Analysis of Coke

(cum. % retained on)						
3 inch sieve.....%	7.7	5.9	8.4	7.8	3.6	5.3
2 inch sieve.....%	45.1	40.1	39.5	45.0	37.8	43.6
1 1/2 inch sieve.....%	77.3	70.1	73.0	75.5	71.7	75.1
1 inch sieve.....%	93.9	93.8	93.1	93.4	94.3	93.9
3/4 inch sieve.....%	95.5	95.9	95.1	95.4	96.4	95.6
1/2 inch sieve.....%	96.4	96.6	96.0	96.2	97.1	96.5
Total -1/2 inch (breeze).....%	3.6	3.4	4.0	3.8	2.9	3.5

ASTM Coke Tumbler Test

Stability Factor.(cum. % + 1 in.)..	54.8	54.7	50.5	51.5	55.1	56.2
Hardness Factor..(cum. % + 1/4 in.)	67.4	70.0	69.3	67.9	69.1	68.0

JIS Coke Tumbler Test

(cum. % retained on)						
30 revs: 50 mm sieve.....%	15.5	9.6	8.8	8.5	16.5	17.1
25 mm sieve.....%	86.4	84.7	84.0	85.8	86.1	86.1
15 mm sieve.....%	93.6	92.6	92.3	92.8	92.9	92.9
150 revs: 50 mm sieve	1.6	3.4	3.6	4.3	3.1	5.4
25 mm sieve.....%	68.2	69.0	64.8	68.2	70.2	69.9
15 mm sieve.....%	81.6	82.5	80.5	81.0	85.9	81.2

Table 11 - Carbonization data

Test Identification Number.....	947	948
Date of Test.....	1982-09-09	1982-09-14
Laboratory Number.....		
Description.....	BLEND X-A	BLEND X-B

Carbonization Data

Net Weight of Charge (wet).....lb	606.2	607.9
Moisture in Charge.....%	3.1	3.1
ASTM Bulk Density (wet).....lb/ft ³	48.7	48.4
Oven Bulk Density (db).....lb/ft ³	51.1	51.3

Carbonization Results

Gross Coking Time.....h:min	9:25	9:20
Maximum Wall Pressure.....lb/in ²	0.89	0.69
Coke Yield Actual.....%	74.9	76.2
Mean Coke Size.....in.	1.95	1.88
Apparent Specific Gravity.....	0.939	0.966

Screen Analysis of Coke

(cum. % retained on)

3 inch sieve.....%	5.8	4.6
2 inch sieve.....%	41.1	37.4
1 1/2 inch sieve.....%	75.0	70.5
1 inch sieve.....%	93.7	93.5
3/4 inch sieve.....%	95.5	95.6
1/2 inch sieve.....%	96.4	96.6
Total -1 1/2 inch (breeze).....%	3.6	3.4

14

ASTM Coke Tumbler Test

Stability Factor.(cum. % + 1 in.)..	54.0	54.3
Hardness Factor..(cum. % + 1/4 in.)	66.5	67.9

JIS Coke Tumbler Test

(cum. % retained on)

30 revs: 50 mm sieve.....%	12.9	15.3
25 mm sieve.....%	86.7	87.0
15 mm sieve.....%	92.4	93.7
150 revs: 50 mm sieve	2.6	4.3
25 mm sieve.....%	69.9	70.2
15 mm sieve.....%	80.5	83.4

Table 12 - Analyses of coke oven charges and resultant cokes

Identification

Test Number.....	929	932	933	928	936	927
Date Charged.....	1982-07-08	1982-07-15	1982-07-20	1982-07-07	1982-07-27	1982-07-06
Description.....	BLEND A	BLEND C	BLEND D	BLEND E	BLEND F	BLEND G

Coke Oven Charge

Laboratory Number.....	3488-82	3489-82	3490-82	3387-82	3491-82	3388-82
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Proximate Analysis (db)

Ash.....%	9.2	9.6	9.3	9.4	9.3	9.3
Volatile Matter....%	23.9	21.0	20.8	23.5	23.9	23.1
Fixed Carbon.....%	66.9	69.4	69.9	67.1	66.8	67.6
Sulphur (db).....%	0.54	0.43	0.42	0.58	0.69	0.50

Resultant Coke

Laboratory Number.....	3685-82	3688-82	3689-82	3684-84	4043-82	3683-82
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Proximate Analysis (db)

Ash.....%	11.9	11.7	11.6	11.4	11.9	11.8
Volatile Matter....%	0.7	0.6	0.6	0.7	1.2	0.7
Fixed Carbon.....%	87.4	87.7	87.8	87.9	86.9	87.5
Sulphur (db).....%	0.41	0.30	0.29	0.40	0.52	0.37

Table 13- Analyses of coke oven charges and resultant cokes

Identification

Test Number.....	947	948
Date Charged.....	1982-09-09	1982-09-14
Description.....	Blend X-A	Blend X-B

Coke Oven Charge

Laboratory Number.....	4187-82	4188-82
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Proximate Analysis (db)

Ash.....%	9.2	9.5
Volatile Matter....%	25.3	23.0
Fixed Carbon.....%	65.5	67.5
Sulphur (db).....%	0.57	0.53

Resultant Coke

Laboratory Number.....	4354-82	4355-82
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Proximate Analysis (db)

Ash.....%	11.9	11.9
Volatile Matter....%	1.3	1.3
Fixed Carbon.....%	86.8	86.8
Sulphur (db).....%	0.47	0.44

STRENGTH INDEX



STABILITY
FACTOR



70

60

50

40

30

20

BLEND C
BLEND D

BLEND X-B
BLEND G
BLEND F

BLEND E
BLEND X-A

65

60

50

40

30

20

10

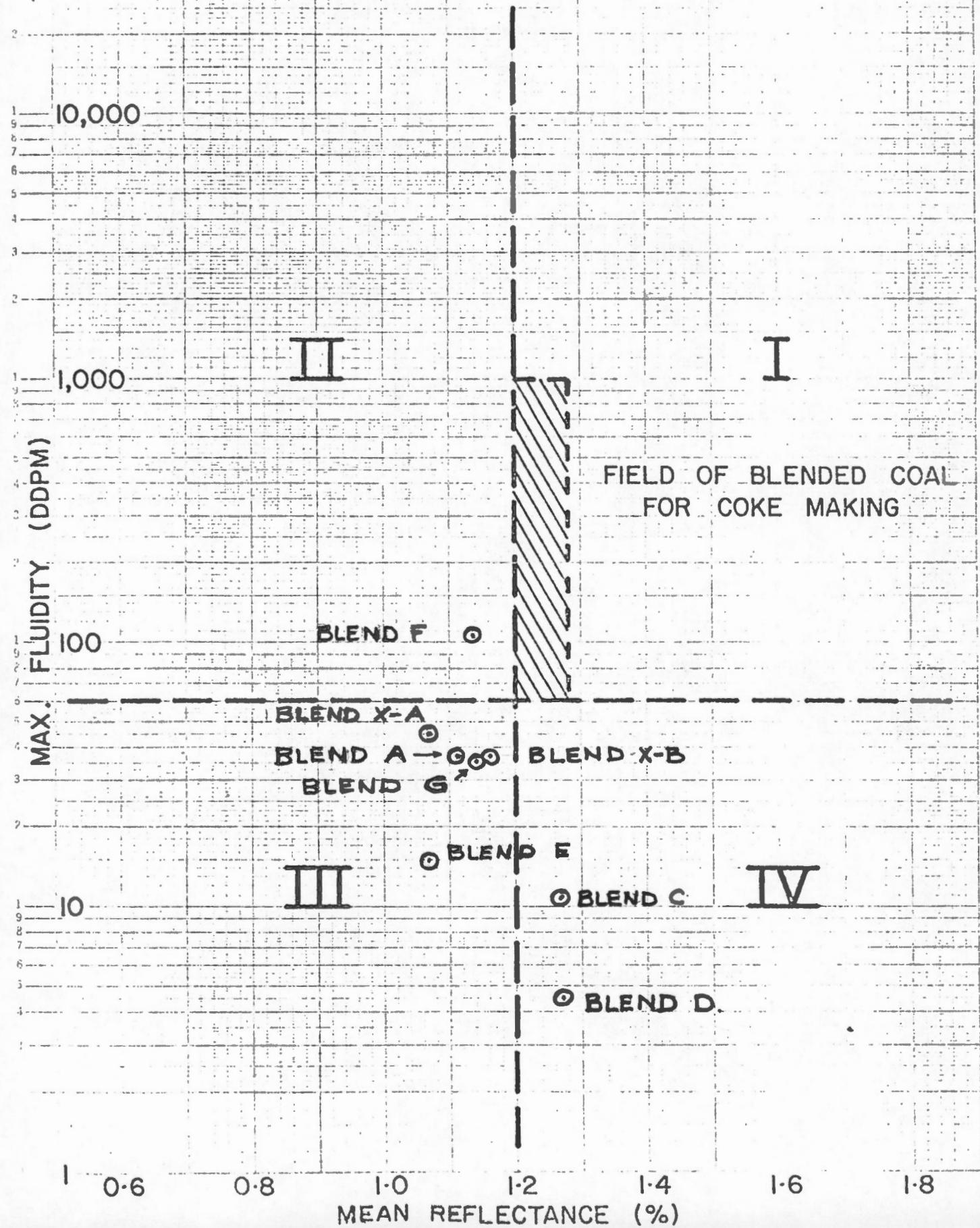
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100 90 80 70 60 50 40 30 20 10 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1

COMPOSITION - BALANCE INDEX

Fig. 1 - Plot of predicted stability factors of coal blends from petrographic data

Figure 2. RELATIONSHIP BETWEEN MAX. FLUIDITY
AND MEAN REFLECTANCE.



APPENDIX 1

Letters dated April 2, 1982, May 6, 1982 and August 9, 1982

from H. S. Stellmach, Manager, Utilization Technology

Crows Nest Resources Limited

Calgary, Alberta



Crows Nest Resources

Eau Claire Place, 525 - 3rd Avenue S.W., Calgary, Alberta (403) 232-4355 **LIMITED**
P.O. Box 2699, Station M, Calgary, Alberta T2P 2M7 Telex 03-822505

April 2, 1982

Mr. J. Jorgensen
Energy Research Laboratories
CANMET
555 Booth Street
Ottawa, Ontario
K1A OG1

Dear John,

Further to our purchase order CN20740 requesting carbonization trials for our Line Creek Extension project, this memo will clarify some of the items discussed earlier.

By this time you should have received the following samples:

<u>Seam</u>	<u>Adit No.</u>	<u>Lab. No.</u>
3 Upper	30	1988
3 Lower	22	1313
4 Upper	21	197
6	25	1692
7	27	1883
8	28	1956
10b	29	1977

We now do not expect to be sending samples for Seams No. 2, 4 Lower or No. 5 as indicated on the purchase order. The sample for Seam 10a will be delayed until June/July.

During the next week we will also be shipping the following blends to you for carbonization:

Blend Lab. No.	A A-2400	B B-2401	C C-2402	D D-2403	E E-2404	F F-2405
Seam No.	%	%	%	%	%	%
3U	10	5			50	50
3L	10	5				
4U	24	12				
6	20	10				
7	36	18				
8	-	20	30	50	50	
10b	-	30	70	50		50

Mr. J. Jorgensen
April 2/82

2

In addition to the standard chemical, physical, petrographic, rheological and coking analyses, I would also like to obtain the following for Blends A, B and C.

1. Reactivity and Post Reaction strength.
2. Linear expansion.
3. Semi-fusinite breakdown for macerals with reflectance below 2%.

In anticipation of CNRL scheduling more carbonization test work at the Western Research Lab, we are shipping duplicate samples of Blends A, B and C to the WRL. From our discussions, I understand that the cost of two of these duplicate tests will be borne by the Energy Research Laboratories.

The results of the above test program are urgently required for the development of our Line Creek Extension project and I would appreciate receiving preliminary information as soon as it is available.

I will be out of the office until April 19, 1982 and will contact you upon my return to discuss any problems that may have arisen. For your information, we expect to set up an additional program of 4 or 5 carbonization trials during June/July, 1982.

Yours very truly,



H. S. Stellmach
Manager, Utilization
Technology



Crows Nest Resources

LIMITED

Eau Claire Place, 525 - 3rd Avenue S.W., Calgary, Alberta (403) 232-4355
 P O Box 2699, Station M, Calgary, Alberta T2P 2M7 Telex 03-822505

May 6, 1982

Mr. J. Jorgensen
 Energy Research Laboratories
 CANMET
 555 Booth Street
 Ottawa, Ontario
 K1A OG1

Dear John,

Further to my letter of April 2, 1982 regarding Line Creek Extension carbonization trials, we will be shipping one additional sample blend to be included under Purchase Order No. CN20740:

<u>Blend/Seam No.</u>	<u>G %</u>
3U	4
3L	6
4U	15
6	10
7	17
8	10
10b	38

The main difference between Blend G and Blend B is in the amount of Seam 8 used. As you know, this is a high inerts seam and our blend carbonization program is designed to assess its performance and limits in a product blend. Your thoughts on its results would also be appreciated.

Thank you for the preliminary information on the individual seams. Please forward also the blend results as soon as they become available.

Best regards,

Yours truly,

A handwritten signature in black ink, appearing to read "H. S. Stellmach".

H. S. Stellmach
 Manager, Utilization
 Technology



Crows Nest Resources

Eau Claire Place, 525 - 3rd Avenue S.W., Calgary, Alberta (403) 232-4355 **LIMITED**
P.O. Box 2699, Station M, Calgary, Alberta T2P 2M7 Telex 03-822505

August 9, 1982.

Mr. J. Jorgensen,
Energy Research Laboratories,
CANMET,
555 Booth Street,
OTTAWA, Ontario,
K1A OG1.

Dear John:

Further to my letter of April 2, 1982, and Purchase Order No. CN-20740, we are shipping two more samples of Line Creek Extension coal to Bells Corner for carbonization. The samples are identified as Line Creek Extension Blends XA-2 and XB. A duplicate sample of Blend XB has also been sent to the Edmonton WRL for carbonization.

I understand that your ovens are extremely busy and some delays may be encountered in completing the tests. However, I do hope that you will be able to squeeze in these samples before excessive sample deterioration has occurred.

Please let me know when the samples are about to be carbonized. If the delays are too long we may have to discard the samples and try again using samples I am keeping in refrigeration.

We are also shipping 27 drums of Line Creek Seam 8 (high semi-fusinite) coal for John Price's Pitch Addition Research Program. The drums will be identified:

CNRL
Pitch Addition Program

I understand aging of coal for this program is not a major concern.

Yours truly,

H.S. Stellmach

H. S. Stellmach,
Manager, Utilization Technology.

cc: Dr. H.A. Hamza, Western Research Laboratory
HSS/ld

